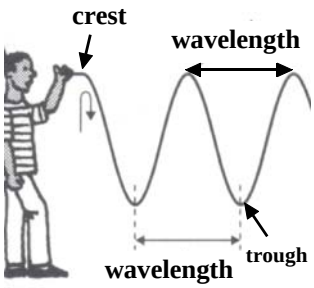
Physics, P1 Energy for the Home

All waves move energy from place to place.

Written by
M J Bradley

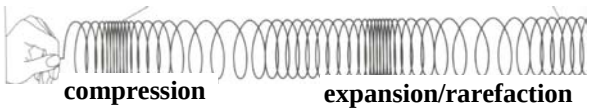


Transverse Waves

These are caused by shaking. Examples are (1) Waves in a string, (2) Water waves, (3) Light. Particles in a transverse wave move up and down as the wave moves through

Longitudinal Waves

These are caused by pushes and stretches. Sound is a longitudinal wave



In a longitudinal wave particles vibrate in the same direction as the wave travels

The link between frequency and wavelength

If the speed of a wave remains constant as frequency increases wavelength decreases

Frequency

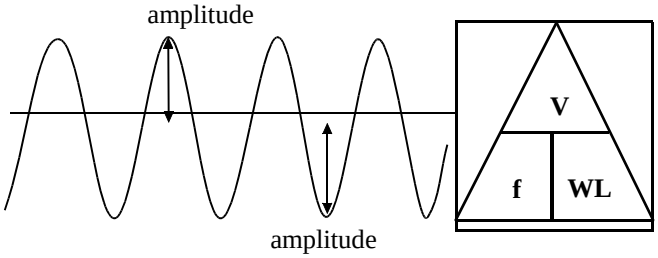
Wave frequency is the number of vibrations or waves which pass a point in one second. It is measured in Hertz, **Hz.**
E.g. 600 waves per second is 600 Hz.
2000 vibrations per second is 2000 Hz or 2KHz

Wave Speed

speed(m/s) = frequency (Hz) x wavelength (m)
or velocity V = f x WL

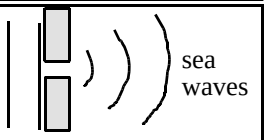
Amplitude

The amplitude of a wave in the sea is the height of a crest or the depth of a trough.



Diffraction

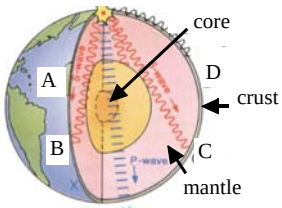
Diffraction is the spreading out of waves when they pass through a gap or pass an object.



Earthquakes:P and S Waves

P-waves are caused by compressions and they are longitudinal. S-waves are caused by shaking and they are transverse

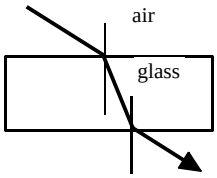
P-waves can travel through liquid and solid. S-waves can travel through solid only. During an earthquake P and S-waves are transmitted through the Earth. Seimographs (they detect Earthquakes) record the arrival of P and S-waves. S waves are not detected on the opposite side of the Earth (between B and C) and this is evidence of a partly liquid core



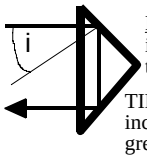
Crust - solid
Mantle - liquid/solid
Core - solid at its centre, liquid in the outer core

Refraction - The bending of Light

When light goes from air into glass it refracts towards the normal.
When light goes from glass into air it refracts away from the normal.
Light refracts because of a change in speed. As it goes into glass it slows down and its wavelength reduces. The frequency remains unchanged



Total Internal Reflection



Road cats-eye. Light is internally reflected inside the glass prism

TIR occurs when the incident ray is at an angle, i, greater than the **critical angle** inside a dense material

The Electromagnetic Spectrum

Highest frequency have the greatest energy

increasing wavelength

Radiotherapy uses gamma rays to kill cancer cells

gamma rays

X-ray

ultraviolet

VIBGYOR colours
visible

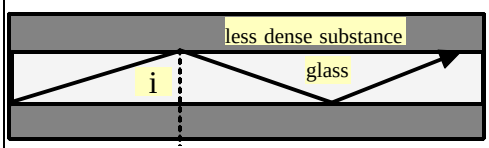
infra-red

microwave

radio waves

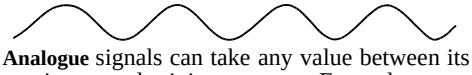
All electromagnetic waves travel at the speed of light.
Gamma rays - Kill cancer cells but can also cause cancer. They are the most dangerous because they have the most energy
X rays - detect broken bones, but can also cause cancer
Ultraviolet - Security marking, but can cause sunburn and skin cancer
Infra-red - heating food, used in fibre optic cable and TV remote control
Microwaves - heating food mobile phones, and communicating with satellites
Radio waves - TV and radio

How Optical Fibre works



The light totally internally reflects at the boundary of the two layers. The incident angle **i** must be greater than the **critical angle**

Analogue and Digital Signals



Analogue signals can take any value between its maximum and minimum range. Examples are a dimmer switch and a mercury thermometer

Digital signals are either on or off. Examples are a push switch and digital meters

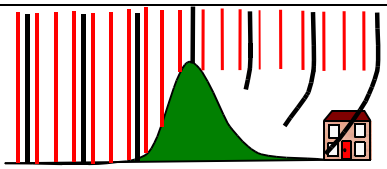
Sunburn and skin cancer

The earths' atmosphere contains ozone which absorbs some of the cancer causing ultra-violet light from the sun

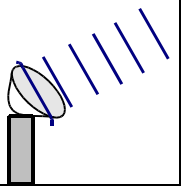
Ozone Layer Chemicals called CFC'S have damaged the ozone layer allowing more UV rays to reach the Earths' surface. They have now been banned in fridges and aerosol sprays

Sun cream and Sun protection Factor (SPF) This is a number which is a guide as to how many times longer you can be in the sunshine without burning. Eg. an SPF of 4 would allow a person to be in the sun 4 times longer before burning

Diffraction is the bending of waves around obstacles or corners. Longer wavelengths diffract the most. This house will not receive short wavelength signals because they do not diffract around the hill



Diffraction can cause some signal loss at the edge of the transmission dish

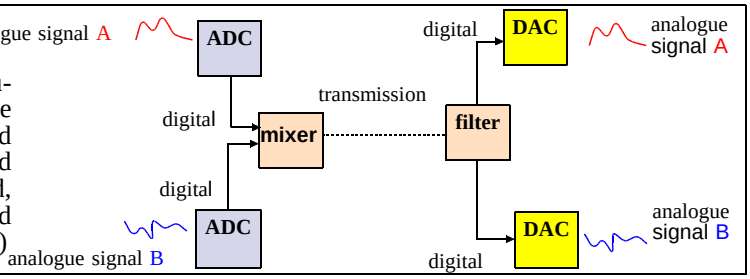


How do microwaves cook food?

Microwaves of just the right frequency are absorbed by water molecules which heat up. In a liquid like soup convection can help spread the heat. Heat can also conduct through more solid foods

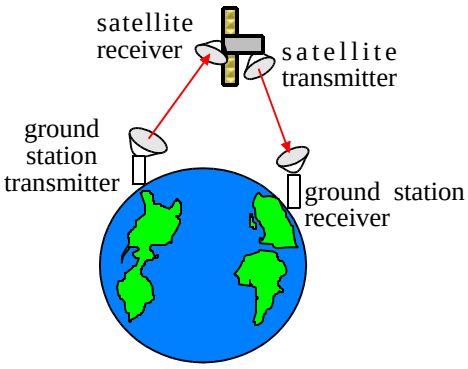
Digital Communications - Advantages

The advantages of digital communication over analogue is that thousands of separate signals can be sent on the same line at the same time and signal quality is easier to maintain. Analogue signals are converted to digital using an analogue to digital converter (**ADC**), are then mixed with separate signals in a process called **multiplexing**, then transmitted, and at their destination split up again into the separate signals and converted back to analogue using a digital to analogue converter (**DAC**)

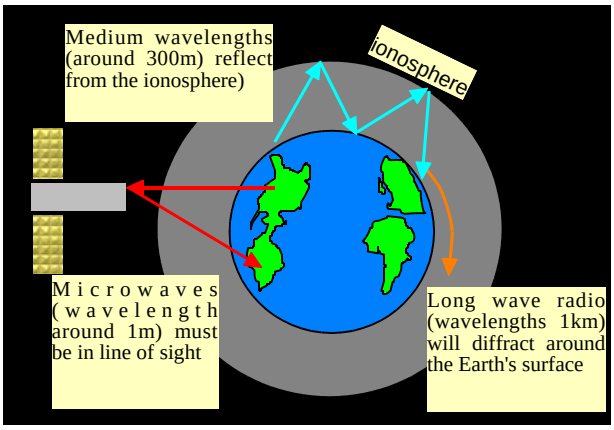


Microwave and Radiowave Communications

Microwave



Microwave communications must be in line of sight. Microwaves are transmitted to a satellite and are re-transmitted back to another location on the Earth. **Medium** radio wavelengths are reflected from the ionosphere back to the Earth's surface. This however is unpredictable and is affected by the sun. **Long** wavelengths can be diffracted around the Earth's surface.

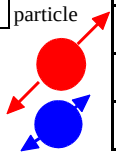


Heat Energy

Every particle in a substance vibrates, this is its heat energy

Temperature

This is a measure of how much the particles in a substance are vibrating. A thermometer measures temperature in degrees Celsius (°c)

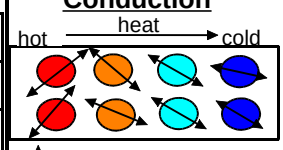


How Heat Travels

	Heat flows by
solid	conduction
liquid/gas	convection
Empty space	radiation

Radiation In radiation heat travels as rays at the speed of light and can travel through empty space

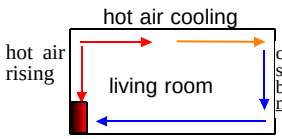
Conduction



hot flame

In conduction heated atoms vibrate more, collide with their neighbours and pass on the heat energy

Convection



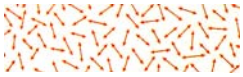
gas fire

In liquids and gases particles are free to move. When they are heated they become less dense and rise taking heat energy with them

Which has the most Heat?

cooler but more heat!

Particles are vibrating a lot so they are very hot but there are not many of them so there is not much heat energy



Particles not vibrating as much so they are cooler but there are a lot of them so the Heat energy is greater

Insulation

loft insulation
double glazing
cavity wall insulation
draft excluders

Heat Insulation: Many insulators contain trapped air. If air is trapped it cannot convect and take heat away

Efficiency = useful energy x 100 (%) input energy

Payback time

time to get money back in heat savings

= installation cost / annual saving

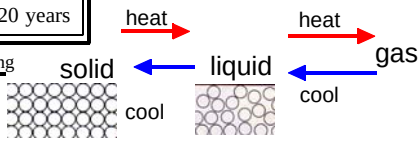
e.g. installation cost = £1000, annual saving = £50. Pay back time = 1000/50 = 20 years

A thermogram is a picture in which different colours represent different temperatures

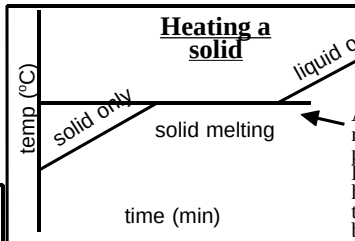
The States of Matter

Solid, liquid and gas

Changing the State of matter



Heating a solid



As the solid is heated its particles get hotter. At the melting point heat is used to break bonds between the particles without any rise in temperature, this is called latent heat. When the solid is melted particles become hotter an the temperature rises. At the boiling point the temperature remains steady and latent heat breaks all the bonds between the particles

Specific Heat Capacity (c)

This is the amount of energy required to raise the temperature of 1 kg of a substance by 1°C. It is different for different materials

specific heat capacity of water = 4200J/kg°C

energy = mass x specific heat capacity x temperature change

(E) (m) (c) (Δt)

E =mcΔt

Example: How much energy will it take to raise the temperature of 3kg of water by 6°C?

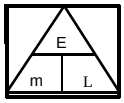
E = mcΔt = 3 x 4200 x 6 = 75600J

Specific Latent Heat (L)

This is the energy required to completely change the state of 1 kg of a substance

energy (J) = mass (kg) x specific latent heat (J/kg)

E = mL



Example: How much energy is required to completely boil 10Kg of water at 100°C?

Latent heat of evaporation = 2500000J/kg

Answer: E = mL = 0.1x 2500000 = 250000J

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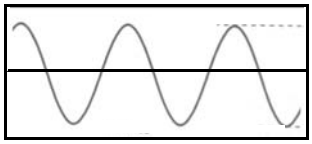
fold along dotted line

1) Label a crest on this wave

2) Label a trough



3) The amplitude is _____ cm

4) The wavelength is _____ cm

5) When the frequency of a wave increases its wavelength gets _____

6) The order of the electromagnetic spectrum starting with the shortest wavelength is .....

7) Electromagnetic waves with a wavelength greater than infrared are _____

8) What is the danger of gamma, X ray and ultra violet rays?

9) What are two uses of gamma rays?

10) What is a use of X rays?

11) What is a use of ultra violet?

12) What are two uses of infrared?

13) What are two uses of microwaves?

14) What is a use of radio waves?

15 All electromagnetic waves travel at the speed of ____

16) Transverse waves are caused by vibrations at _____angles to the direction the wave travels

17) Longitudinal waves are caused by vibrations in the same _____ as the wave travels.

18) What type of wave are P waves (push) in the Earth?

19) What type of waves are S (shake) waves in the Earth?

20) Which part of the Earth's structure is solid rock?

21) Which part of the Earth is a solid/liquid?

22) What is the centre of the Earth called?

23) Show how light internally reflects along this fibre optic cable

24) Heat travels from _____ to _____

25) Heat travels through solids by _____

26) Heat travels through liquids and gases by _____

27) Heat travels through empty space by _____

28) A thermogram is a picture where the colours represent different _____

29) Specific heat capacity is the energy required to raise the temperature of _____ of a substance by _____

30) energy = mass x specific heat capacity x temp change
How can this equation be written in symbols?

31) How much energy is required to raise the temperature of 3kg of water by 10 degrees. Specific heat capacity of water is 4200J/kg^{o}c (4)

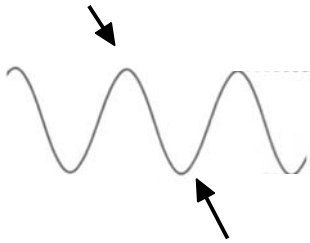
32) Why does the temperature of boiling water remain at 100^{o}C even when you continue to heat it?

33) What is specific latent heat?

34) How much energy is required to boil 2kg of water already at 100^{o}C? Latent heat of water is 2 260 000J/Kg (4)

35) In convection hot air becomes less _____ and _____

1) crest



2)trough

3) 0.6 cm

4) 1.4 cm

5) less

6) gamma, X ray, ultra violet, visible, infra-red, microwave, radio

7) microwave and radio

8) They can cause cancer

9) Kill bacteria and can kill cancer cells

10) To detect broken bones

11) For viewing security marking

12) cooking food and TV remote control

13) Cooking food and mobile phones

14) Communications including TV

15) Light

16) Right

17) direction

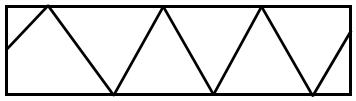
18) longitudinal

19) Transverse

20) Crust

21) Mantle

22) Core



24) hot, cold

25) conduction

26) convection

27) radiation

28) temperatures

29) 1kg, 1^{o}C

30) E = MCΔT

31) E = MCΔT = 3x4200x10 = 1260000J

32) Energy is being used to break bonds

33) the energy required to melt or boil 1Kg of a substance

34) E = mL = 2 x 2 260 000 = 4 520 000J

35) dense rises

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fold along dotted line

35) Sketch a graph of temperature against time for heating ice from - 10ºC to 100ºC. Explain what is happening in each part of the graph

36) For insulation what is meant by pay back time?

37) pay back time = ?

38) Fibreglass is a good insulator because it contains ..... so ..... cannot happen

39) efficiency = _____?_____ x 100
?

40) A gas fire uses 7000J/S of chemical energy and outputs 5000J/S of heat energy to a room. What is its efficiency?

41) Microwaves are part of the _____ spectrum

42) Microwaves only heat _____

43) Microwave cooking works by water in the outer food layers absorbing _____ and the heat then _____ to other areas

44) Mobile phones work using _____

45) There are concerns that mobile phones could damage health because.....

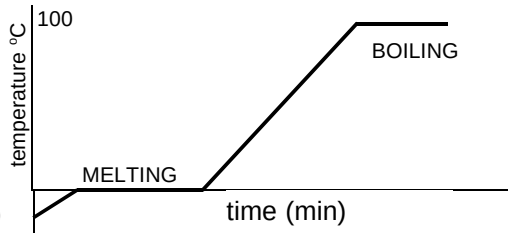
46) In microwave communications transmitters and receivers must be in _____ of sight. In radio communications long waves are able to _____ around the Earths surface. _____ waves are able to reflect off the _____ back to the Earths surface.

47) A digital signal is either _____ or _____

48) An analogue signal ranges anywhere between a _____ and a _____ value.

49) This represents a _____ signal 

50) A sound wave has a velocity of 340 m/s and a frequency of 1000 Hz. What is its wavelength?

35) 

36) time to get your money back in heat savings

37) cost of installation/annual saving

38) air convection

39) <u>useful energy</u> x 100
input energy

40) efficiency = 5000/7000 = 71.4%

41) electromagnetic

42) water

43) microwaves, conducts

44) microwaves

45) heating effect of microwaves on the brain

46) line, diffract, medium, ionosphere

47) on off

48) maximum minimum

49) digital

50) v=fxWL, WL = V/F = 340/1000 = 0.34 m

P1 TEST

NAME _____

List of useful formulae

efficiency = useful energy output X 100
total energy input

energy = mass x specific heat capacity x temperature change

energy = mass x specific latent heat

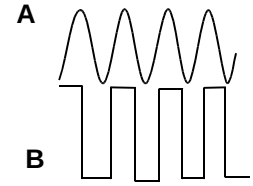
wave speed = frequency x wavelength

1) Devices can be analogue or digital.

(a) Give two examples of an analogue device _____[2]

(b) Give two examples of a digital device _____[2]

(c) The diagrams show two signals. (i) Which is analogue? How can you tell? _____
_____[2]

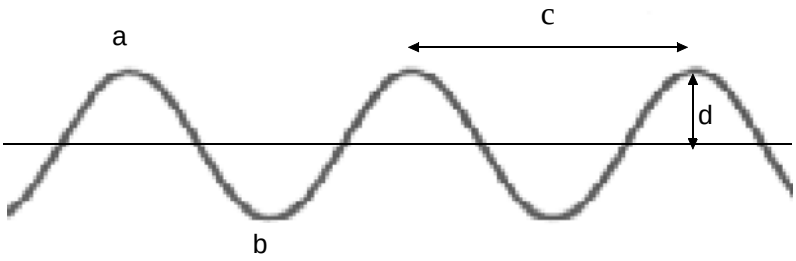


(ii) Which is digital? How can you tell? _____
_____[2]

(d) The telecommunications industry uses digital signals. One reason is that digital signals can be multiplexed. What does this mean? _____
_____[2]

(e) State another advantage of using digital signals for communications _____
_____[1]

2) Look at the diagram of waves on the sea surface.



a) What type of waves are these?

_____[1]

b) Which letter shows the wave amplitude?

_____[1]

c) Which letter shows a wave crest?_____[1]

d) Which letter shows a wave trough?____[1]

e) Which letter shows the wavelength? ___[1]

3a) Sound also travels as a wave. What type of wave is sound?_____[1]

b) If a sound wave has a speed of 340m/s and a frequency of 1000Hz, what is its wavelength?

_____

_____[4]

c) If the speed of the sound wave remains at 340m/s and the frequency is increased above 1000Hz what will happen to its wavelength? _____[1]

d) If another sound wave has a wavelength of 0.1m and a a speed of 340m/s, what is its frequency?

_____

_____[4]

4) Robin and Leslie's house costs a lot to heat. They need more insulation in their house. **Look at the information in the table.**

insulation method	cost to fit	money saved each year in fuel bills	pay-back time
cavity wall insulation	£800	£200	4 years
double glazing	£5000	£250	
draught excluders	£50	£100	6 months
loft insulation	£200	£100	2 years

(a) (i) What does pay-back time mean?

_____

_____

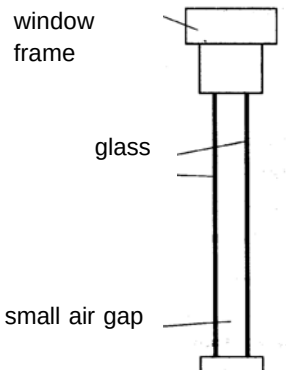
_____

(ii) Calculate the pay-back time for **double glazing** _____

_____

(b) **Look at the diagram of the double glazing.** The small air gap reduces energy transfer through the window. **Explain how**

In your answer write about conduction and convection



_____

_____

_____

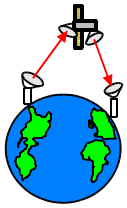
_____

_____[3]

5) Describe how light and infra-red can pass along optical fibre

_____[1]

6) Micro and radiowaves can carry information.. Satellites use microwaves for global transmission. Look at the diagram and explain how microwaves are transmitted and received

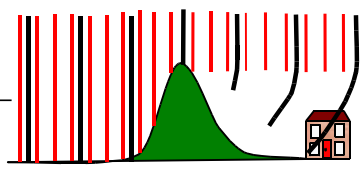


_____

_____[3]

7) Mountains and other large obstacles can have a big effect on radio reception in our homes. Short wavelengths are affected the most and longer wavelengths the least.

Look at the diagram and explain why reception for longer wavelengths is okay



_____

_____[2]

8) (a) Look at this list of waves.

gamma rays, infra-red, microwaves, radio waves, sound waves, ultra-violet, visible light, X-rays

(i) Which wave can be used to treat cancer? Choose from the list _____[1]

(ii) Ultra-violet rays can harm the human body. Explain how. _____ [1]

(iii) Doctors use X-rays to look for broken bones. They do not use gamma rays. Explain why _____ [1]

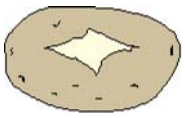
(b) (i) Nick puts a large potato in his microwave oven. He switches the microwave oven on and after a few minutes the potato is completely cooked, even in the centre. **Explain how the microwaves cook the food**

_____

_____

_____ [3]

(ii) He wraps the hot potato in shiny aluminium foil. The foil keeps the potato hot for a long time.



Explain how the foil keeps the potato hot

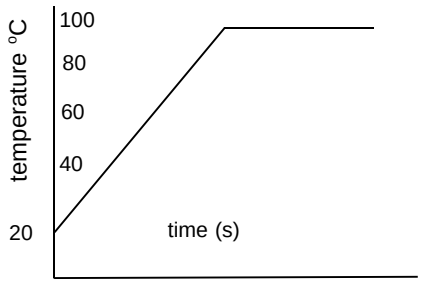
_____[2]

9) This question is about the energy required to heat and boil water.

Useful data: specific heat capacity of water = 4200J/kg°C

Latent heat of evaporation = 2600000J/kg

A student heated 5kg of water and plotted temperature against time. Use the graph to answer the following



(a) What was the initial temperature of the water? _____[1]

(b) What is the final temperature of the water _____[1]

(c) What is meant by specific heat capacity? _____

_____[1]

(d) How much energy was required to raise the water temperature to its boiling point?

_____[3]

(e) Why does the water temperature remain steady at the boiling point even when heat is still being supplied?

_____[1]

(f) What is meant by specific latent heat? _____

_____[1]

(g) How much energy is required to completely boil the water when it has reached its boiling point?

_____

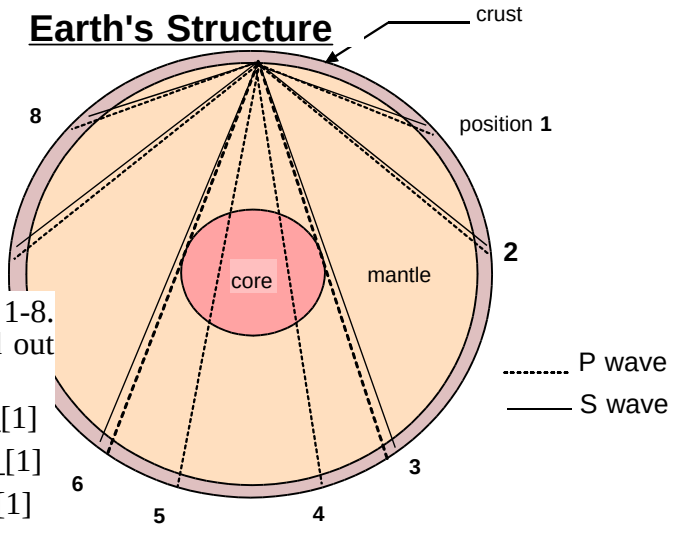
_____[1]

10) Scientists have studied how waves travel through the Earth after an earthquake. P and S waves can be detected at different points on the Earth's surface using a seismograph.

(a) What type of wave is a P wave_____[1]

(b) What type of wave is an S wave?_____[1]

(c) Which wave travels fastest? _____[1]



(d) **Look at the diagram.** A seismograph is located at positions 1-8. The simplified diagram opposite shows how waves were spread out after an earthquake.

i) What waves were detected at positions 1 - 3? _____[1]

ii) What waves were detected at positions 4 and 5? _____[1]

iii) What waves were detected at positions 6 - 8? _____[1]

iv) How do these observations make scientists believe that part of the inside of the Earth is liquid? _____

_____

_____[2]